Energy+Environmental Economics

Public Tool Adoption Module and ELCC Module Overview

02 December 2014

Purpose of this Webinar

+ **Per AB 327, the Commission must ensure that under the NEM Successor Tariff "…customer-sited renewable distributed energy continues to grow sustainably."**
  - One possible way to assess sustainability is to model customer adoption of DERs under different tariff/contract designs in the Public Tool.
  - The first part of this webinar is to describe E3's proposed methodology for modeling customer adoption of distributed energy resources (DERs) in the Public Tool.
+ **AB 327 also requires the Commission to evaluate the costs and benefits of the successor tariff/contract to all customers and to the electrical grid**
  - One aspect of costs and benefits is the capacity value of DERs.
  - The second purpose of this webinar is to provide an overview of the Effective Load Carrying Capability (ELCC) analysis used to measure the capacity value of intermittent renewable resources in the Public Tool.
+ **We will not be discussing any of the stakeholder proposals received in response to the September 5th Administrative Law Judge's Ruling seeking post-workshop comments. We will discuss stakeholder comments at a subsequent workshop.**

ADOPTION MODULE OVERVIEW

Adoption Module

- **Principal questions - Given a suite of DER installation options (various technologies and sizing) with different customer financial propositions, <u>how much</u> and <u>how fast</u> will consumers adopt?**
- **Methodology based largely on NREL's *Solar Deployment System Model** (SolarDS) that simulates the potential adoption of solar PV**
  - Methodology also used in E3's Market Driven DG Calculator for the WECC

*http://www.nrel.gov/docs/fy10osti/45832.pdf

Step-by-Step Module Overview

1. **For each customer bin, calculate benefit-cost ratio for different possible DER technology/sizing installations**
   - Benefit-Cost ratio = utility bill savings (or FiT credits) / cost of DER system
2. **Convert benefit-cost ratio into implied payback period**
3. **Forecast ultimate market adoption penetration**
4. **Scale down forecast by technical potential**
5. **Allocate forecast among discrete DER installation options**
6. **Calculate annual installations**

Customer Bins

- **Utility customers are sorted into bins based on their most defining characteristics**
  - Utility
  - Customer type
  - Usage
  - Climate Zone
- **Each of these bins represents a certain number of customers with the potential to install a DER system**

DER Options

- **Up to 8 different DER technology options**
  - PV
  - Up to 3 PV + storage options (energy rate arbitrage, capacity rate arbitrage, maximize grid benefits)
  - Wind
  - Biogas
  - Biomass
  - Fuel cell
- **3 sizing options: For each technology customers can install a system size equal to a percentage of their annual energy load**
  - 33%
  - 67%
  - 100%
- **For each customer, up to 24 different options (8 techs x 3 sizes)**
- **E3 is examining the possibility of modeling systems sized over 100% of usage. In this case we would have up to 32 options.**

Step 1: Financial Proposition

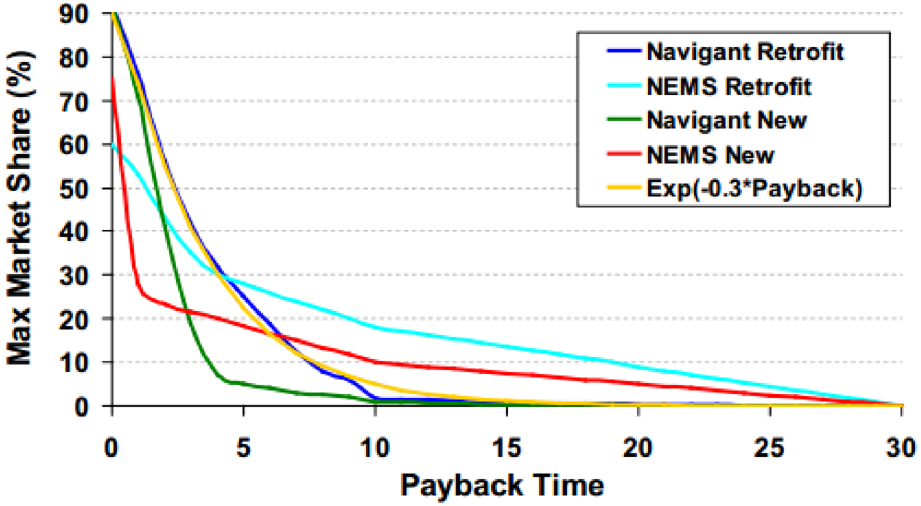
- **Financial proposition to the customer is a function of**
  - NEM Bill Savings or FiT Payments
    - Represented as the present value (PV) of all bill savings relative to not having installed the DER system over the economic life of the system
    - Utility rates are assumed to escalate at a user-defined fixed rate
  - Cost of the DER system
    - Represented as the PV of all payments to the installer or third party
      - Can be formulated as lease, PPA, or upfront purchase
      - Changes over time with technological advances, changes in incentive levels, etc.

Step 1 (con't) Financial Proposition Metrics

- **Two financial metrics result…**
  - Method 1: PV Benefit/Cost Ratio
    - = PV (Utility Bill Savings or FiT Payments) / PV (Cost of the DER System)
  - Method 2: PV Savings
    - = PV (Utility Bill Savings or FiT Payments) – PV (Cost of the DER System)
- **For each technology, the most economic system size is selected for further evaluation**
  - User selects Method 1, Method 2, or a combination as basis for this determination

Step 2: Payback Curve

- Many studies* measure the relationship between maximum solar PV market share and simple payback period

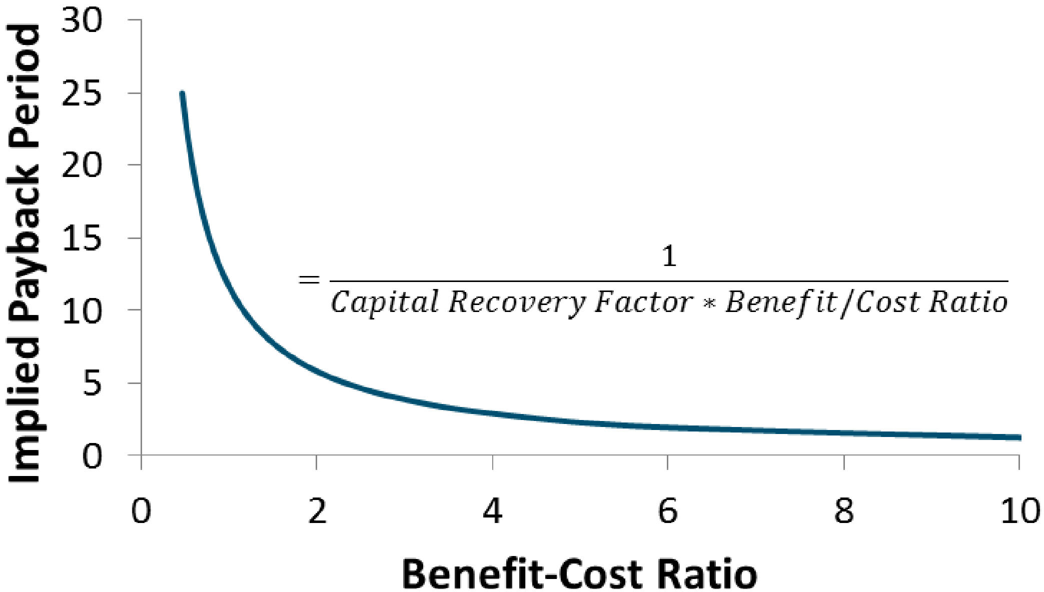


- Simple payback period is defined as the number of years until cumulative cash flow is positive
- However, with many DER systems being installed through a lease (or levelized financing agreement) with no upfront costs, cumulative cash flow is positive from day 1 and therefore simple payback period is not applicable

*Kastovich et al., 1982; Paidipati et al., 2008; R.W. Beck, 2009

Step 2: Implied Payback Period

- In order to use the market adoption curves that rely on simple payback period, E3 translates the previously calculated benefit-cost ratio into an implied simple payback period via the relationship shown below
- This relationship is based on a cash flow with an upfront cost and constant annual benefits
- The capital recovery factor is dependent upon 1) assumed discount rate and 2) assumed economic lifetime of the technology



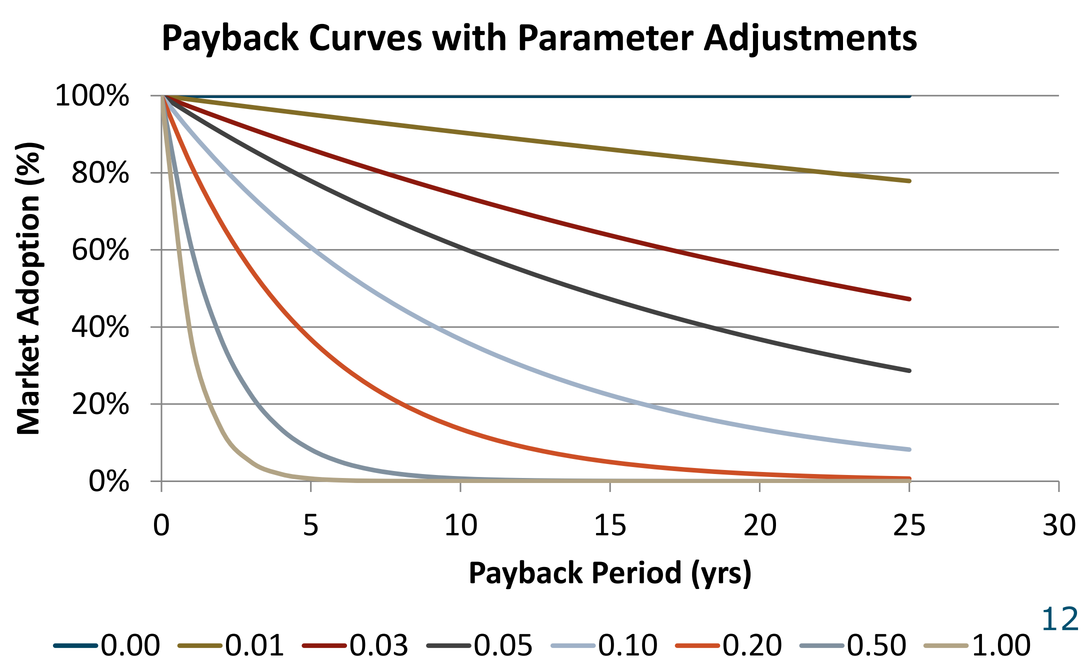
Step 3: Market Adoptions

- Using empirically observed adoption relationships, literature suggests an appropriate functional form for maximum market adoption is a function of the mathematical constant e

$$maximum\ market\ adoption = e^{-payback\ sensitivity * simple\ payback\ period}$$

- The payback sensitivity parameter can be set depending on customer characteristics (i.e. residential vs. commercial) or other various factors. Default parameters will be calibrated to historical adoptions

- Given up to 8 technology choices now facing the customer (optimal sizing was determined in Step 1), a maximum market adoption is calculated for each technology



Step 4: Technical Potential

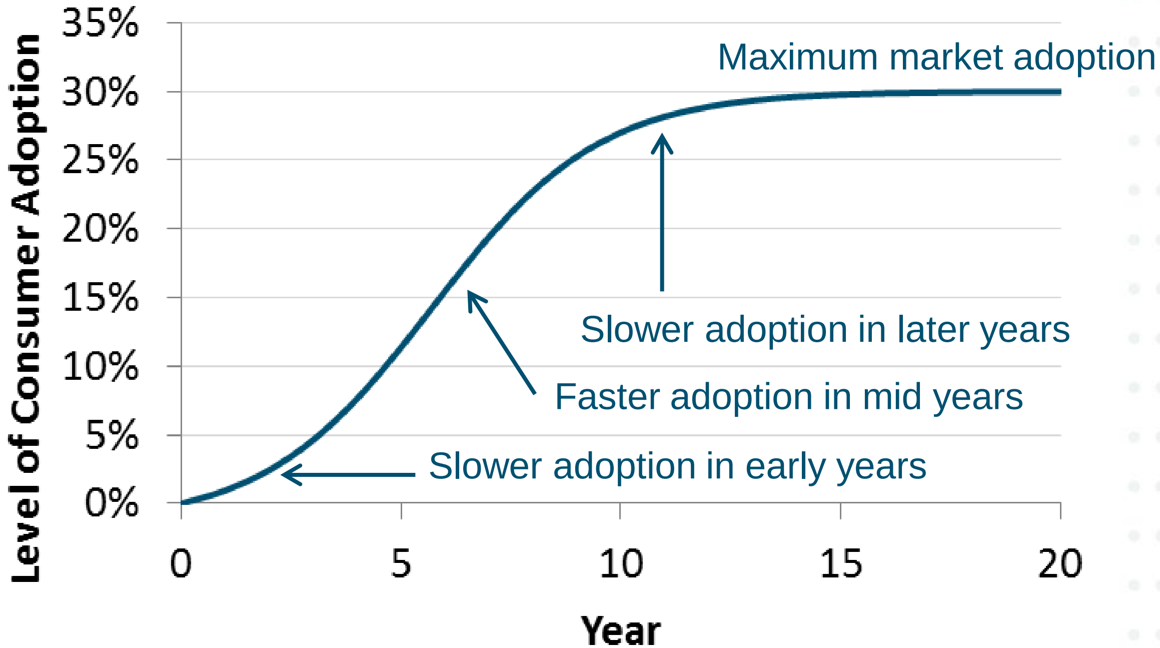
- **Maximum market adoption is then scaled down by the appropriate technical potential factors (user flexible) given the customer class and technology type**
  - For instance, biogas technical potential might be very small in the residential rate class but significant in the agricultural rate class

Step 5: Customer Choice

- **Forecasted maximum market adoptions are then allocated proportionally such that total installations across technologies sum to the installation forecast for the single highest projected technology**
- **Example: One technology's market potential is forecasted to be 10%**
  - Ultimate adoptions for that technology are forecasted to be 10%
- **Example: Two technologies' market potentials are forecasted at 10%**
  - Since an individual customer can only install one technology, half of all adopters are assumed to install one technology and half the other
  - Ultimate adoptions for each technology are forecasted to be 5%
    - 5% + 5% = 10%
- **Example: Three technologies' market potential are forecasted at 10%, 10% and 5%, respectively**
  - Some adopters might prefer the 5% option, but less than either of the 10% options
  - Ultimate adoptions for each technology are forecasted to be 4%, 4% and 2% which keeps projected adoptions proportional to the original projections
    - 4% + 4% + 2% = 10%

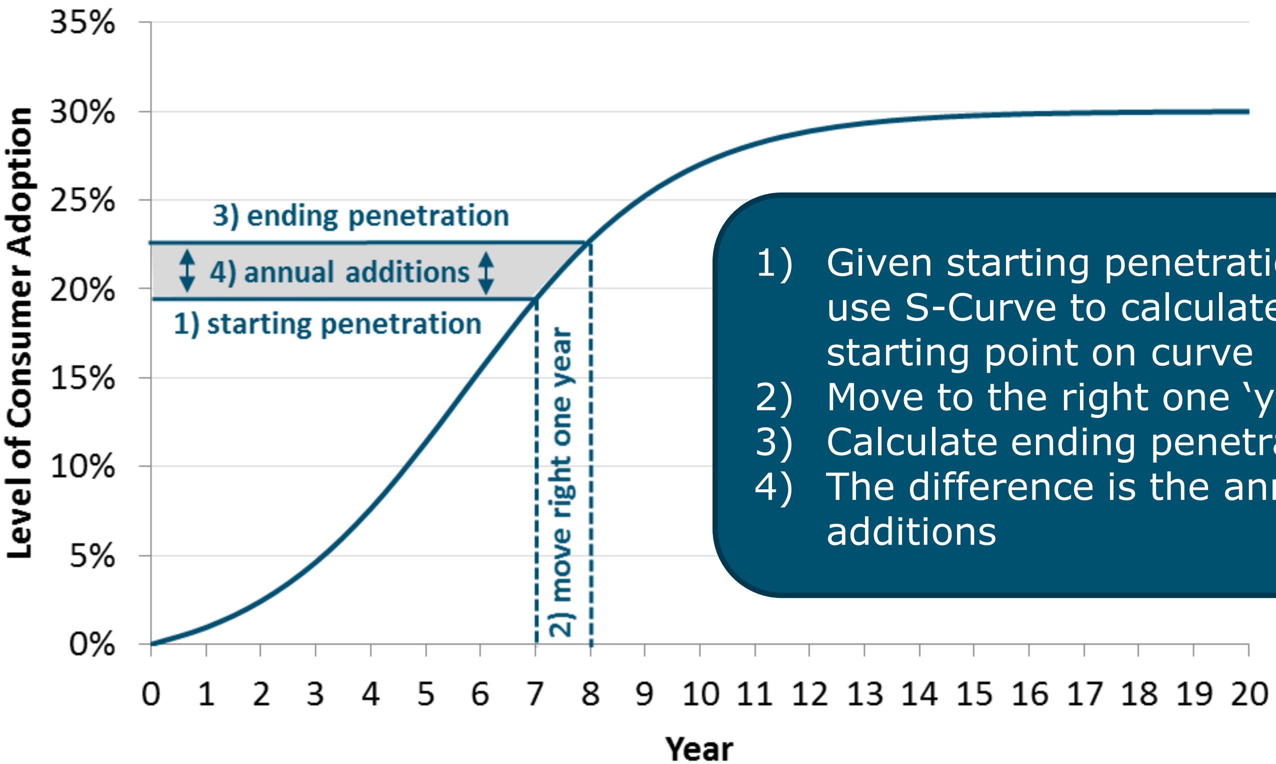
Step 6: Rate of Adoption

- Empirical observations and literature suggest the rate of consumer technology adoptions mirror an "S-Curve" shown below
- Two parameters (user flexible) govern the shape of the S-Curve and characterize the rate at which both early and late adopters install the technology



Step 6 (con't) Year-On-Year Installations

- Given that the economics of DER change from year to year (due to changes in utility rates, capital costs, and/or fuel costs), a new maximum market adoption and corresponding S-Curve must be re-calculated annually
- Steps for calculating annual additions are below



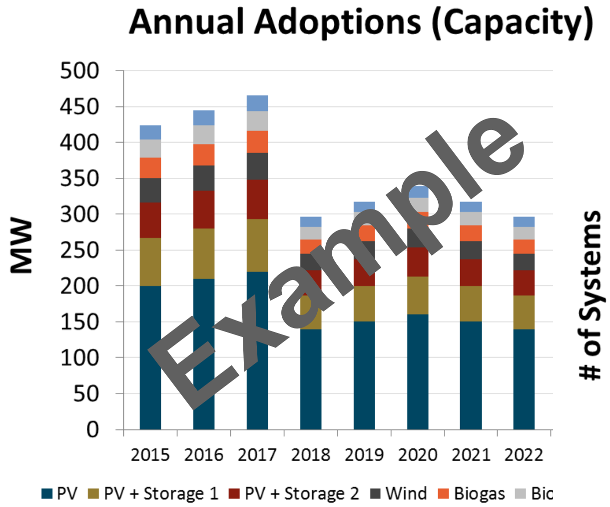
1) Given starting penetration, use S-Curve to calculate starting point on curve
2) Move to the right one 'year'
3) Calculate ending penetration
4) The difference is the annual additions

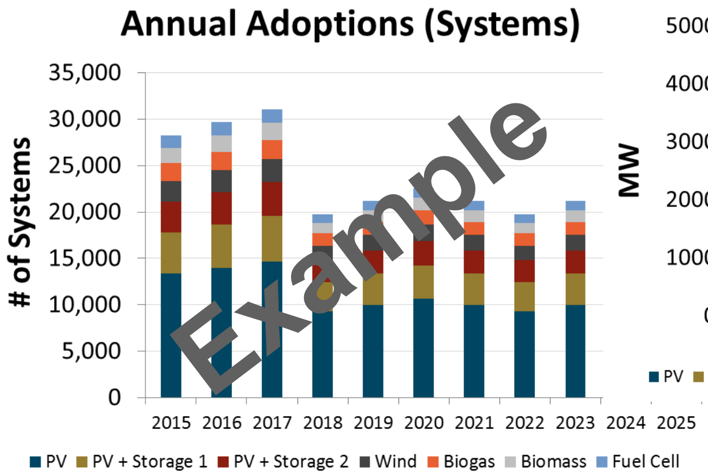
Calculating All Bins and All Years

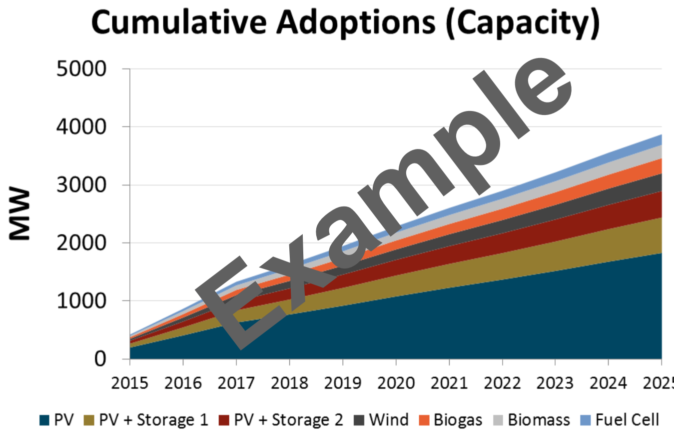
- The adoption module treats each customer bin as its own, independent market
- In a given year for each customer bin, it calculates the total MW and number of systems installed by technology
- Using total installations across all customer bins, it re-calculates utility rates given the new billing determinants that result from DER adoption
- It then repeats this process for the next year and so forth

Adoption Module Results

- **<u>Users may also override module calculations and input their own adoption projections</u>**
- **Model Outputs:**
  - # of System Installs (by bin, by year, by technology)
  - MW of Installs (by bin, by year, by technology)
  - % of Customer adoption (by bin, by year, by technology)







ELCC MODULE OVERVIEW

ELCC Module Overview

+ **Principal question – Given a portfolio of variable utility-scale and customer-sited DER resources, what are the aggregate and individual technology contributions to system capacity needs?**

+ **Methodology required by statute - Senate Bill 2 (2011)**

  *"…the commission shall determine the effective load carrying capacity of wind and solar energy resources on the California electrical grid. The commission **shall use** those **effective load carrying capacity** values in establishing the contribution of wind and solar energy resources toward meeting the resource adequacy requirements established pursuant to Section 380."*

+ **Methodology based largely on effective load carrying capability (ELCC) as calculated in E3's open-source RECAP* model**

*https://ethree.com/public_projects/recap.php

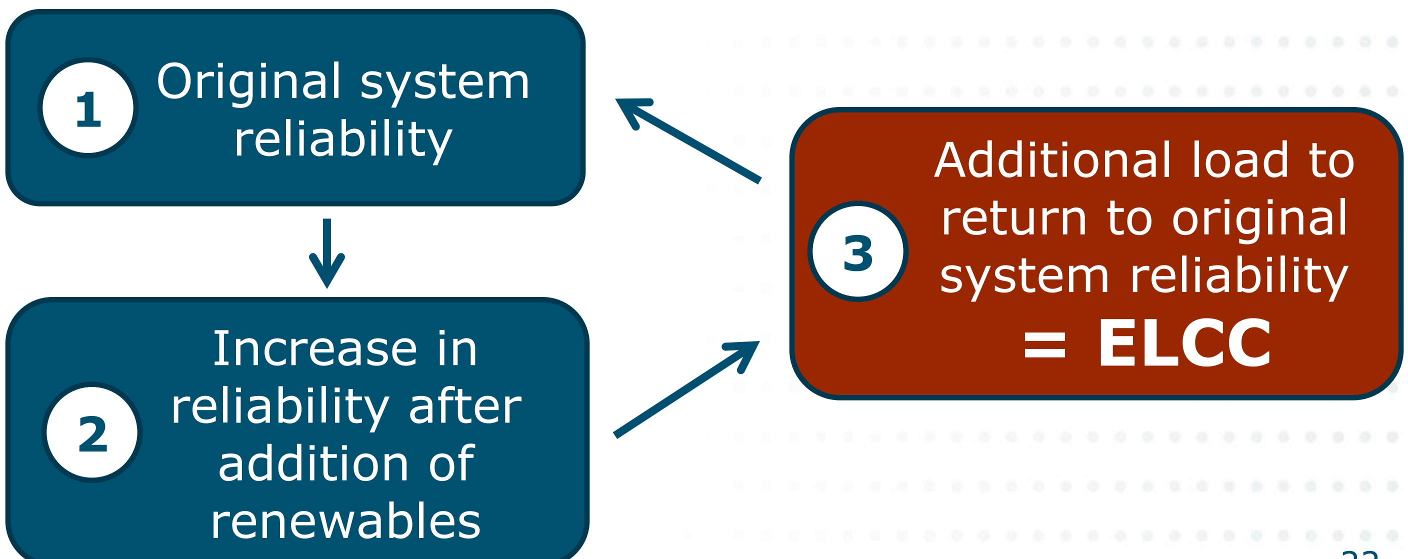
Background on ELCC

+ **This contribution to system capacity needs is commonly calculated using the effective load carrying capability (ELCC)**
+ **ELCC first established in 1960's* and has been a common metric for conventional generation**
+ **In the past 10 years, this metric has been adapted to variable generation**
  - E3 has used ELCC in multiple analyses and CPUC proceedings
    - 2013 Net Energy Metering (NEM) Evaluation for CPUC
    - Used in CPUC 2012 Long-Term Procurement Planning (LTPP) proceedings
    - E3's *Investigating a Higher Renewable Portfolio Standard in California*

*Garver, L.L., *Effective Load Carrying Capability of Generating Units. Power Apparatus and Systems*, Aug. 1966

ELCC Methodology

+ **The addition of variable renewable resources to a power system increases system reliability**
+ **Adding load to a power system decreases system reliability**
+ **ELCC is defined as the amount of load that can be added to a system after the addition of variable renewable resources while maintaining the same level of system reliability**

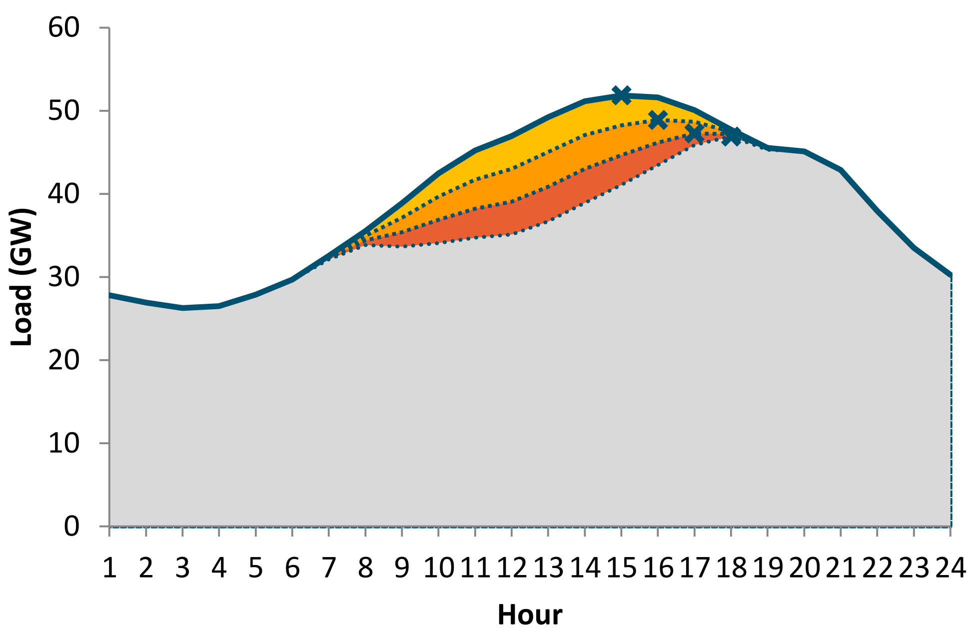


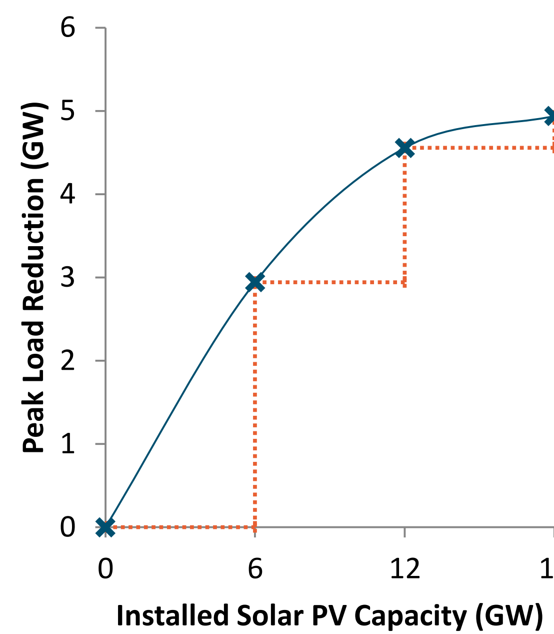
Factors that affect ELCC

+ **Coincidence with load**
  - Production shapes with higher coincidence to aggregate load have higher ELCC
  - Solar located further north and west relative to load leads to higher ELCC (due to better coincidence with late-afternoon summer load)
+ **Production variability**
  - Statistically, the possibility of low production reduces ELCC
+ **Location**
  - Distributed resources avoid transmission and distribution losses, improving ELCC – this can be measured explicitly or implicitly
+ **Existing quantity of variable generation**
  - Common resource types show diminishing marginal returns, in other words, ELCC decreases over time as penetrations increase

The impact of high renewable penetrations

- **A resource's contribution towards reliability depends on the other resources on the system**
- **The diminishing marginal peak load impact of solar PV is illustrative of this concept**
  - While the first increment of solar PV has a relatively large impact on peak, it also shifts the "net peak" to a later hour in the in day
  - This shift reduces the coincidence of the solar profile and the net peak such that additional solar resources have a smaller impact on the net peak





Portfolio Capacity Value

- **The portfolio capacity value is the relevant capacity calculation for resource planning**
  - E3 will use this metric to determine total capacity contribution (ELCC) of system resources, including DER
- **ELCC will be used in the Public Tool to calculate**
  - CAISO system resource adequacy (RA) requirements
    - Necessary to calculate revenue requirement capacity costs and overall rate levels. For example, higher ELCC values decrease the cost of procuring incremental RA capacity in the revenue requirement.
  - Avoided costs related to DG
    - Used to calculate cost impact
    - Also used in value-based FIT calculations

Allocating Portfolio Capacity Value

+ **Annual portfolio capacity value for system RA requirements <u>is equal to</u> the annual ELCC used to calculate avoided costs**
+ **ELCC used to calculate avoided costs related to DG can be specified on a <u>vintaged</u> or a <u>non-vintaged</u> basis**
  - Vintaged ELCC does not change over time for a given tranche of DG
  - Non-vintaged ELCC changes over time per mix of system resources
    - Each annual technology vintage could have a different ELCC than the previous year's technology vintage
+ **Users may specify annual capacity value by technology or can allow the model to calculate ELCC based on annual system resource mix**

ELCC Example: Solar + Wind

- **The Public Tool will be seeded with a regression formula that represents a multi-dimensional surface for a large number of RECAP runs in order to calculate the portfolio and marginal ELCC associated with different penetrations of variable technologies**
- **Marginal capacity value is calculated as the partial slope of each resource**
- **Example:**
  - Year 1: Portfolio ELCC = 390 MW @ 500 MW solar penetration and 500 MW wind penetration
  - Year 2: Portfolio ELCC = 510 MW @ 1000 MW solar penetration and 1000 MW wind penetration
  - Vintaged ELCC contribution = 120 MW (510 – 390)
  - Solar & Wind ELCC contribution = 60 MW each
    - Individual marginal ELCC values of 55 MW calibrated upwards to match portfolio ELCC contribution